Improving the Efficiency of Liquid Feed Use In Dairy Rations

Honors Project Thesis

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Abstract

Milk production and milk fat synthesis depend much upon the provision of adequate energy to the cow. Non-fiber carbohydrates (NFC) from cereal grains are used in the dairy industry as the main way to provide increased energy to the animal. Liquid feeds (LF) are NFC byproducts from food processing. The LF used in this study was Quality Liquid Feed's TMR 20, which is made from molasses (from sugar processing), corn steep liquor (from wet milling of corn for sweeteners) and whey (from cheese manufacturing). LF also helps reduce sorting behavior and increase palatability of feeds. The excess sugars found in LF provide more calories but can promote rumen acidosis. The low rumen pH associated with acidosis can inhibit fiber-degrading bacterial populations, decreasing digestibility and feed intake. To help prevent acidosis, farmers use Rumensin (R), an antibiotic ionophore that inhibits lactic acid-producing bacteria and makes feed conversion more efficient, but can inhibit milk fat through rumen metabolism. After approval of R for dairy rations, some farmers have noted that, when combined with diets containing rapidly available carbohydrates, it can depress milk fat concentration, which costs them considerable profit.

The project objective was to investigate whether positive effects from feeding two concentrations of LF are more likely as rumen-available starch is diluted with soybean hulls and the presence of R. The different levels of LF and NFC help to pinpoint how and when sugar supplementation would be most effective. The hypothesis was sugar supplementation at a moderate level would prevent acidosis and improve digestive efficiency without depressing milk fat. To test this hypothesis, we measured total tract digestibility, milk fat production, volatile fatty acid (VFA) concentrations, and ruminal

fermentation characteristics. This project consisted of a 5-cow digestibility trial within a larger, 60-cow production trial using five treatment diets. Cows were fed 1) control diet at 40% NFC, 2) 40% NFC + 3.25% LF, 3) 37% NFC + 3.25% LF, 4) 37% NFC + 6.25% LF or 5) 37% NFC + 6.25% LF + R. Two rumen-cannulated and three non-cannulated lactating Holstein cows were fed each of the treatment diets for five 4-week periods. Total tract digestibility was determined using Cr_2O_3 dosed into the rumen of the cannulated cows or from capsules for the non-cannulated cows. Rumen pH and VFAs were measured at 0, 3, 6 and 9 hours after feeding.

The digestibility results showed no significant difference between treatments. Milk fat also showed no significant differences, meaning that R did not depress production. VFA total, acetate/proprionate ratio, and butyrate concentrations showed no treatment differences.

Knowing how to formulate diets that contain R but do not depress milk fat or cause acidosis is valuable to the dairy industry. For an average milk production level, milk fat depression could decrease the cow's profit potential by a third or more. LF provides a relatively cheap source of calories while stimulating or stabilizing total feed intake of mixed rations, which may help prevent milk fat depression and improve efficiency of feed conversion into milk components.

Introduction

In order to feed dairy cows efficiently, knowledge is needed to formulate diets that will accurately provide enough calories and protein for a cow to produce as much milk as possible. Variability in the carbohydrate formulation of dairy rations is a problem facing the industry today. This variability leads to 1) problems associated with rumen acidosis and related metabolic problems, 2) varying effects of carbohydrate availability and pH on rumen microbial protein synthesis, and 3) dietary interactions associated with carbohydrate nutrition such as rumen-degraded protein (RDP) (Firkins 2001).

Carbohydrates are one of the most important aspects of dairy nutrition because they provide the most energy and make up the most space in rations. There are two types of carbohydrates in the diet: fiber and non-fiber carbohydrates (NFC). Fiber is crucial in the diet to stimulate chewing during eating and rumination, which buffers the pH of the rumen and prevents problems associated with low rumen pH, such as acidosis. Acidosis is a condition in which the rumen pH drops below a critical threshold and can decrease digestibility and intake of feed, inhibit bacterial populations, and possibly initiate rumen perakeratosis or ulceration of the rumen. NFC is important in providing calories to the dairy cow, but NFC can cause problems if the starch is degraded too quickly and lactic acid is produced, lowering the rumen pH. Diets high in grain and sugar cause problems in the rumen, so many nutritionists do not add any additional sugar. Too much rumen-degraded carbohydrate can decrease pH so much that fiber-degrading bacteria are inhibited, decreasing digestibility of the entire ration. (Firkins 2002)

Despite the potential problems with sugars leading to acidosis, recent research has documented potential benefits that are not well researched. Liquids feeds are used in the dairy industry to provide more energy to the animal, increase palatability of feeds, and reduce sorting behaviors. The liquid feed used in this study was Quality Liquid Feed's TMR 20. It is made out of molasses, corn steep liquor, and whey. Besides the increase in calories that the sugars provide, liquid feeds make rations less dusty. Ground feeds often become powdery as the particle size becomes smaller, and the addition of liquid feeds in the diet can improve the texture of the feed and make it more attractive to the animal. Additionally, the smell and sugary taste of molasses can increase the palatability of feeds. Liquid feeds reduce the behavior common to cattle called sorting. This is when the cows “sort” or choose their favorite part of the mixed rations to eat first and then eat the remaining feed over time. This can be detrimental to the rumen environment as most cows will eat the grain first, causing rumen pH to drop because the grain starch is rapidly fermented and there is no fiber to stimulate rumination; later, the more timid cows in a group must eat the remainder of the diet that is deficient in calories and possibly protein. The addition of liquid feed can help the mixed ration stick together, so that all cows eat all feeds equally over time (Broderick 2004).

Liquid feeds are also beneficial because they are made from byproducts of other industries. Byproducts are important in feeding today’s dairy cows cheaply and more effectively, and they provide a means to economically dispose of waste products. Molasses found in the liquid feed is a byproduct of sugar cane processing. Corn steep liquor is a byproduct of processing corn for ethanol as a renewable fuel or for production of high fructose corn syrup used in soda pop and other products, and whey is a byproduct of cheese-making. Feeding byproducts to animals helps the animals nutritionally, helps the environment by decreasing waste put into landfills, and helps the manufacturers by making their products cheaper through sales of what would otherwise be waste. Soybean hulls are an additional byproduct fed to cattle. Soybean hulls contain a lot of fiber, which stimulate rumination or slow the rate of degradation of carbohydrate in the rumen when they dilute corn grain. Rumensin, while not a byproduct, is an antibiotic ionophore that is commonly added to cattle feed because it makes the feed consumed be used in the body more efficiently. As part of the process for FDA approval, this antibiotic was shown to be different than others used in human therapy and is very unlikely to confer antibiotic resistance genes to bacteria. Feed conversion to energy becomes more efficient with this product because Rumensin inhibits methane production and promotes the metabolic pathway that produces propionate, a volatile fatty acid used to synthesize glucose (Russell 2003). Dairy producers have complained that Rumensin has decreased milk fat synthesis in their dairy cows. This is a problem because there is a substantial premium for milk fat in the dairy industry.

Objectives

The aims of the trial were to investigate whether sugar supplementation at a moderate level would prevent acidosis and improve digestibility without depressing milk fat. Also, the objective was to pinpoint how and when sugar supplementation would be most effective in lactating dairy cow rations.

Materials and Methods

Digestibility Trial:

Two rumen-cannulated and three non-cannulated lactating Holstein cows were fed 5 treatment diets for five 4-week periods. The four-weeks consisted of a three-week diet adjustment period with a week of sampling. The experimental design was a 5x5 Latin Square. The cows were dosed with the digestibility marker chromic oxide (Cr_2O_3)

every twelve hours during sample collection periods. Rumen-cannulated cows were dosed chromic oxide pellets directly into their rumens and non-cannulated cows were dosed with a bolus. Fecal samples were taken 8 times over a 4-day period. TMR and refusal samples were taken every day during the sample collection period. Rumen content samples were taken at hours 0, 3, 6 and 9 for the cannulated cows. Rumen content samples were taken through stomach tubes once per period for intact cows.

Production Trial:

The production trial consisted of 12 cows per treatment diet. The cows were fed a common diet during their 2-week covariance period and then switched to their treatment for 12 weeks. The cows were all on bST and were milked twice daily, with milk samples being analyzed at DHI. All cows were housed in a tie-stall barn at the OSU Waterman Dairy. Figure 1 shows the diet components in the treatment diets.

Figure 1

Treatment Diet Contents:

	40% NFC		37% NFC		
	Control	3.25% LF	3.25% LF	6.5% LF	6.5% LF+R
Corn silage	30.0	30.0	30.0	30.0	30.0
Alfalfa hay, chopped	15.0	15.0	15.0	15.0	15.0
Whole cottonseed	8.00	8.00	8.00	8.00	8.00
Liquid Feed	0.00	3.25	3.25	6.50	6.50
Corn, ground	26.4	23.4	18.0	16.0	16.0
Soybean hulls	5.52	5.66	11.7	10.4	10.4
Dry distillers grains	4.00	4.00	4.00	4.00	4.00
Blood meal, ring dried	0.80	0.80	0.80	0.80	0.80
Soybean meal, expeller	4.00	4.00	4.00	4.00	4.00
Soybean meal, solvent	4.00	4.00	3.40	3.40	3.40
Urea[1]	0.26	0.00	0.00	0.00	0.00
Dicalcium phosphate	0.30	0.30	0.30	0.30	0.30
Limestone	0.90	0.80	0.80	0.80	0.80
Magnesium oxide	0.12	0.12	0.12	0.12	0.12
Potassium chloride	0.07	0.07	0.07	0.07	0.07
Trace-mineralized salt[2]	0.50	0.50	0.50	0.50	0.50
Vitamin premix[3]	0.13	0.13	0.13	0.13	0.13
Rumensin premix[4]	0.00	0.00	0.00	0.00	0.007

[1] Urea added so equal CP as the low liquid feed diets (17.3%) at at least 8.0% RDP more than the requirement (NRC, 2001). Diets were formulated at 17.3% CP and 11.0% RDP for control and 3.25% LF diets and 18.5% CP and 12.2% RDP for 6.25% LF diets.

[2] Contained 0.10, 38.0, 58.0, and 0.04% Mg, Na, Cl and S; 5000, 7500, 2500, 6000, 100, 60, and 50 ppm of Fe, Zn, Cu, Mn, I, Se and Co.

[3] Approximately 136000, 34000, and 600 IU per cow per day.

[4] Provides 11.5g of Rumensin ® per ton of DM of the total diet.

Results

The most beneficial ration appears to be the diet containing 3.25% LF in 37% NFC because it stimulated feed intake which increased the yields of milk, milk fat and milk protein. The production of milk fat, 3.5% fat-corrected milk and energy-corrected milk were higher for the cows fed that diet than cows fed the control or the diet containing 3.25% LF and 40% NFC. The addition of LF did not depress milk fat even at high levels or when R was included in the diet. This means that the diets were formulated and balanced correctly for rumen available carbohydrate digestibility. The addition of liquid feed increased DMI at 37% NFC when compared to the control. There were no differences in digestibility found among treatments. There were no significant differences among treatments in organic matter, fiber, or nitrogen digestibility. Figure 2 shows the results of digestibility and milk production from the trial treatments.

Figure 2

	40% NFC		37% NFC				
	Control	3.25% LF	3.25% LF	6.5% LF	6.5% LF + R	SE	P
Digestibility Trial							
DMI, kg/d	25.2	25.7	24.5	26.3	26.8	1.5	NS
OM digestibility, %	76.3	75.1	75.7	76.3	75.5	2.3	NS
NDF digestibility, %	52.1	44.8	49.6	51.8	41.1	5.5	NS
N digestibility, %	70.5	65.8	67.7	67.4	68.7	2.5	NS
Production Trial							
DMI, kg/d	23.9	23.9bc	25.2ab	26.0a	24.5bc	0.7	0.10
Milk, kg/d	39.7	39.8	41.6	40.7	40.2	0.86	NS
Fat, %	3.31	3.42	3.34	3.29	3.31	0.07	NS
Fat, kg/d	1.31b	1.28b	1.39a	1.33b	1.32b	0.03	0.08
Protein,%	2.93a	2.82b	2.85b	2.85b	2.83b	0.02	0.01
Protein, kg/d	1.16	1.13	1.18	1.16	1.14	0.03	NS
3.5% fat-corrected milk, kg/d	37.9b	37.2b	39.7a	38.5ab	38.0ab	0.77	0.08
Energy-corrected milk, kg/d	26.2b	25.7b	27.4a	26.5ab	26.2b	0.54	0.09

No evidence of acidosis occurred in the trial as there were no changes in acetate concentrations or acetate: propionate ratios. If acidosis had occurred, acetate would have increased as the lactic-acid and acetate-producing bacteria population increased.

Ruminal nitrogen for microorganism growth was also not a limiting factor; ammonia N were 10mg/dL, and most nutritionists accept 5 mg/dL as being sufficient. This lack of differences means that the differences shown in the milk components were due to the diet differences, not a difference in digestibility or fermentation characteristics. No extraneous factors caused the differences seen in the production trial. Figure 3 shows the ruminal ammonia and volatile fatty acids produced from each of the treatments. No significant differences were found from any of the diets.

Figure 3

	40% NFC		37% NFC				
	Control	3.25% LF	3.25% LF	6.5% LF	6.5% LF+R	SE	P
Rumen NH_3 mg/dL[1]	11.5	13.3	14.9	11.7	13.5	1.0	NS
Total VFA[2], mM	106	107	113	110	99	19	NS
Individual VFA, mol/100mol							
Acetate	64.9	65.6	64.8	64.9	64.8	1.8	NS
Propionate	21.0	20.7	20.0	20.9	21.1	1.6	NS
Butyrate	10.7	10.2	11.2	10.8	10.1	0.6	NS
Isobutyrate	0.81	0.83	0.90	0.75	0.91	0.08	NS
Isovalerate	1.37	1.29	1.40	1.25	1.38	0.17	NS
Valerate	1.38	1.39	1.71	1.31	1.63	0.21	NS
BCVFA[3]	3.58	3.51	4.01	3.31	3.92	0.41	NS
Acetate:propionate	3.20	3.25	3.36	3.13	3.17	0.32	NS

[1] NH_3 is ammonia
[2] VFA stands for volatile fatty acids
[3] BCVFA stands for branched chain volatile fatty acids

This research demonstrates that liquid feeds have the potential to increase profitability of dairy enterprises when fed correctly. Substituting LF for rumen-degraded starch while reducing NFC stimulated feed intake and milk fat production, so liquid feeds would be beneficial in many dairy rations.

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